GEORGIA INSTITUTE OF TECHNOLOGY — OFFICE OF CONTRACT ADMINISTRATION

PROJECT ADMINISTRATION DATA SHEET

[X] ORIGINAL [ ] REVISION NO. ____

Project No. A-3434 J. GAGLIANO (GTRI)/GIT DATE 12-15-82

Project Director: ~~James J. McSkimin~~ School/Lab EML

Sponsor: Naval Research Laboratory

Type Agreement: Contract N00014-83-C-2009 (ROA N00014-79-H-0108 Rev. 4)

Award Period: From 11/26/82 To ~~11/25/83~~ 11/25/84 (Performance) 11/25/83 (Reports)

Sponsor Amount: Total Estimated: $130,522 Funded: $ 17,000

Cost Sharing Amount: $ ____ Cost Sharing No: ____

Title: 85.5 GHz Dual Polarization Radiometer

ADMINISTRATIVE DATA

OCA Contact Frank H. Huff X4820

1) Sponsor Technical Contact:

Notice of Award
12/3/82
OR

2) Sponsor Admin/Contractual Matters:

Thomas A. Bryant
ONR RR
Ga. Inst. of Tech.
206 O'Keefe
Atlanta, Ga. 30332
(404) 881-4213

Defense Priority Rating: DO-S1 under DMS Reg 1

Military Security Classification: (Unclassified)

(or) Company/Industrial Proprietary: ____

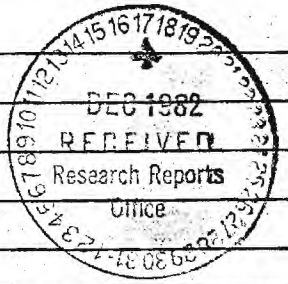
RESTRICTIONS

See Attached Govt Supplemental Information Sheet for Additional Requirements.

Travel: Foreign travel must have prior approval – Contact OCA in each case. Domestic travel requires sponsor approval where total will exceed greater of $500 or 125% of approved proposal budget category.

Equipment: Title vests with Govt Unit cost proposed. Note that radiometer is a deliverable & classified as Materials & Supplies

COMMENTS:



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Other ____

FORM OCA 4-781 (Rev 982)

GEORGIA INSTITUTE OF TECHNOLOGY OFFICE OF CONTRACT ADMINISTRATION

SPONSORED PROJECT TERMINATION/CLOSEOUT SHEET

SR342 2-F-13

Date 6/25/84

Project No. A-3434 ~~School~~/Lab EML:

Includes Subproject No.(s)

Project Director(s) J. A. Gagliano GTRI / ~~Sch~~

Sponsor Naval Research Laboratory

Title "85.5 GHz Dual Polarization Radiometer"

Effective Completion Date: 2/25/84 (Performance) 2/25/84 * (Reports)

*however expenses incurred after 2/25/84 to complete the final report are allowable. (memo dtd. 3/19/84)

Grant/Contract Closeout Actions Remaining:

- [ ] None
- [x] Final Invoice or Final Fiscal Report
- [x] Closing Documents
- [x] Final Report of Inventions
- [x] Govt. Property Inventory & Related Certificate
- [ ] Classified Material Certificate
- [ ] Other

Continues Project No. Continued by Project No.

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Form OCA 60:1028

A-3434

Monthly Technical Report No. 1

and

Monthly Cost and Performance Report No. 1

Report Period
November 25 through December 25, 1982

Report Prepared
January 17, 1983

DEVELOPMENT OF AN 85.5 GHz DUAL POLARIZATION RADIOMETER

J. J. McSheehy

Contract N00014-82-C-2009
EES Project A-3434

Effective Date: 11/26/82
Expiration Date: 11/25/83

Prepared for

Naval Research Laboratory
Washington, D.C. 20375

Prepared by

Engineering Experiment Station
Georgia Institute of Technology
Atlanta, Georgia 30332

WORK PERFORMED DURING THIS PERIOD

All major RF components are now in the procurement process and orders should be let within 30 days. Project staffing and resource allocations have been finalized.

PROBLEMS ENCOUNTERED DURING THIS PERIOD

No problems were encountered during this period.

WORK TO BE PERFORMED DURING THE NEXT PERIOD

System design and procurement will continue.

Project Number A-3434

Cost Information

The following charges have been incurred against the contract during the period December 1 to December 31, 1982 .

	Expended	Encumbered
Personal Services (PS)	249.66	-0-
Materials and Supplies	-0-	30.00
Computer	-0-	-0-
Benefits (@ 21% of PS)	53.80	-0-
Travel	-0-	-0-
Overhead (@ 47.2% of Direct Charges)	143.23	-0-
Equipment	-0-	-0-
TOTAL	446.69	30.00

The breakdown of personal services is as follows:

	Dollars	Approximate Hours
Principal Research Scientists/Engineers	-0-	-0-
Senior Research Scientists/Engineers	-0-	-0-
Research Scientists II/Engineers II	-0-	-0-
Research Scientists I/Engineers I	249.66	17
Technicians/Draftsmen	-0-	-0-
Students	-0-	-0-
Secretarial/Clerical/Other	-0-	-0-
TOTAL	249.66	17

The current financial status of the contract is as follows:

	Budget as Proposed	Expended	Encumbered*	Free Balance
Personal Services (PS)	6110.00	249.66	-0-	5860.34
Materials & Supplies	3922.00	-0-	30.00	3892.00
Computer	-0-	-0-	-0-	-0-
Benefits	1283.00	53.80	-0-	1229.20
Travel & Shipping	233.00	-0-	-0-	233.00
Overhead	5452.00	143.23	-0-	5308.77
Equipment	-0-	-0-	-0-	-0-
TOTAL	$17,000.00	$446.69	$30.00	$16,523.31

*47.2% Overhead on all direct charge encumbrances.

Based on present partial funding, the funding and equivalent man hours are sufficient to complete the task. Approximately 0.4% of the proposed task has been completed.

A-3434

Monthly Technical Report No. 2

and

Monthly Cost and Performance Report No. 2

Report Period
December 25 through January 25, 1983

Report Prepared
March 9, 1983

DEVELOPMENT OF AN 85.5 GHz DUAL POLARIZATION RADIOMETER

J. J. McSheehy

Contract N00014-82-C-2009
EES Project A-3434

Effective Date: 11/26/82
Expiration Date: 11/25/83

Prepared for

Naval Research Laboratory
Washington, D. C. 20375

Prepared by

Engineering Experiment Station
Georgia Institute of Technology
Atlanta, Georgia 30332

WORK PERFORMED DURING THIS PERIOD

Orders have been placed for all RF components not being fabricated at Georgia Tech. The mixer/LO assembly is scheduled for delivery from TRG before 4/1/83. All other RF components should be delivered by 5/15. The orthomode transducer design is complete and has been sent to the metal shop. Design of the RF enclosure and quasi-optical beam steering components is underway and a mold for casting the calibration reference loads is being made.

The major components of the control unit have been ordered and several of the control circuits are in the breadboard stage.

PROBLEMS ENCOUNTERED DURING THIS PERIOD

No problems were encountered.

WORK TO BE PERFORMED DURING THE NEXT PERIOD

System design and fabrication will continue.

Project Number A-3434

Cost Information

The following charges have been incurred against the contract during the period January 1 to January 31, 1983 .

	Expended	Encumbered
Personal Services (PS)	2,299.27	-0-
Materials and Supplies	183.73	21,965.20
Computer	-0-	-0-
Benefits (@ 21% of PS)	364.21	-0-
Travel	-0-	-0-
Overhead (@ 47.2% of Direct Charges)	1,343.88	-0-
Equipment	-0-	-0-
TOTAL	$4,191.09	$21,965.20

The breakdown of personal services is as follows:

	Dollars	Approximate Hours
Principal Research Scientists/Engineers	-0-	-0-
Senior Research Scientists/Engineers	893.89	40
Research Scientists II/Engineers II	-0-	-0-
Research Scientists I/Engineers I	674.10	46
Technicians/Draftsmen	-0-	-0-
Students	702.60	82
Secretarial/Clerical/Other	28.68	4
TOTAL	$2,299.27	172

The current financial status of the contract is as follows:

	Budget as Proposed	Expended	Encumbered*	Free Balance
Personal Services (PS)	6,110.00	2,548.93	-0-	3,561.07
Materials & Supplies	3,922.00	183.73	21,995.20	(18,256.93)
Computer	-0-	-0-	-0-	-0-
Benefits	1,283.00	418.01	-0-	864.99
Travel & Shipping	233.00	-0-	-0-	233.00
Overhead	5,452.00	1,487.11	-0-	3,964.89
Equipment	-0-	-0-	-0-	-0-
TOTAL	$17,000.00	$4,637.78	$21,995.20	($9,632.98)

*47.2% Overhead on all direct charge encumbrances.

Based on present partial funding, the funding and equivalent man hours are sufficient to complete the task. Approximately 157% of the proposed task has been completed.

Monthly Technical Report No. 3

and

Monthly Cost and Performance Report No. 3

Report Period
January 25 through February 25, 1983

Report Prepared
March 9, 1983

DEVELOPMENT OF AN 85.5 GHz DUAL POLARIZATION RADIOMETER

J. J. McSheehy

Contract N00014-82-C-2009
EES Project A-3434

Effective Date: 11/26/82
Expiration Date: 11/25/83

Prepared for

Naval Research Laboratory
Washington, D. C. 20375

Prepared by

Engineering Experiment Station
Georgia Institute of Technology
Atlanta, Georgia 30332

WORK PERFORMED DURING THIS PERIOD

Design and fabrication are continuing. An order was placed with Siemens Corporation for the motor and controller which will drive the chopper blade. The mold for casting the calibration reference free-space loads was completed and fabrication of these components has started.

PROBLEMS ENCOUNTERED DURING THIS PERIOD

The present partial funding situation has resulted in an overrun of $14,000 and could cause work on this project to stop unless more funds are received soon.

WORK TO BE PERFORMED DURING THE NEXT PERIOD

A design review at NRL has been scheduled for April 5, 1983. Preparations for this meeting, fabrication of RF components, and testing of control circuit designs will continue.

Project Number A-3434

Cost Information

The following charges have been incurred against the contract during the period February 1 to February 28, 1983 .

	Expended	Encumbered
Personal Services (PS)	2,327.49	-0-
Materials and Supplies	919.13	43.40
Computer	-0-	-0-
Benefits (@ 21% of PS)	226.77	-0-
Travel	-0-	-0-
Overhead (@ 47.2% of Direct Charges)	1,639.44	-0-
Equipment	-0-	-0-
TOTAL	$5,112.83	$ 43.40

The breakdown of personal services is as follows:

	Dollars	Approximate Hours
Principal Research Scientists/Engineers	-0-	-0-
Senior Research Scientists/Engineers	893.89	40
Research Scientists II/Engineers II	-0-	-0-
Research Scientists I/Engineers I	-0-	-0-
Technicians/Draftsmen	108.80	11
Students	1,303.67	151
Secretarial/Clerical/Other	21.13	3
TOTAL	$2,327.49	205

The current financial status of the contract is as follows:

	Budget as Proposed	Expended	Encumbered*	Free Balance
Personal Services (PS)	6,110.00	4,876.42	-0-	1,233.58
Materials & Supplies	3,922.00	1,102.86	22,038.60	(19,219.46)
Computer	-0-	-0-	-0-	-0-
Benefits	1,283.00	644.78	-0-	638.22
Travel & Shipping	233.00	-0-	-0-	233.00
Overhead	5,452.00	3,126.55	-0-	2,325.45
Equipment	-0-	-0-	-0-	-0-
TOTAL	$17,000.00	$9,750.61	$22,038.60	($14,789.21)

*47.2% Overhead on all direct charge encumbrances.

Based on present partial funding. Approximately 187% of the proposed task has been completed.

A-3434

Monthly Technical Report No. 4

and

Monthly Cost and Performance Report No. 4

Report Period
February 25 through March 25, 1983

Report Prepared
April 13, 1983

DEVELOPMENT OF AN 85.5 GHz DUAL POLARIZATION RADIOMETER

J.J. McSheehy

Contract N00014-82-C-2009
EES Project A-3434

Effective Date: 11/26/82
Expiration Date: 11/25/83

Prepared for

Naval Research Laboratory
Washington, D. C. 20375

Prepared by

Engineering Experiment Station
Georgia Institute of Technology
Atlanta, Georgia 30332

WORK PERFORMED DURING THIS PERIOD

The preliminary design was approved at a meeting with J. Hollinger at NRL on 5 April. The orthomode transducer has been built and is ready for polishing and gold plating. Alpha Industries delivered the dual channel mixer/preamp/LO assembly and their testing data show average noise figures of less than 4.0 dB for each channel over the required 100 to 1000 MHz bandwidth. The chopper motor and drive circuit were delivered and will be assembled for testing. The horn antenna was delivered but has some visible defects in the internal corrugations. KHI Electroform, the vendor, has agreed to replace this item if these defects affect the loss or radiation pattern. Until it is actually tested, it is difficult to judge whether the defects will affect performance or are merely cosmetic.

PROBLEMS ENCOUNTERED DURING THIS PERIOD

No problems were encountered during this period.

WORK TO BE PERFORMED DURING THE NEXT PERIOD

The front end RF components will be assembled and tested to verify vendor test data and specifications. Fabrication of the remaining mechanical parts has been started and should be complete in about 60 days. Breadboarding and P.C. layout work will continue for the control and monitor circuits.

Project Number A-3434

Cost Information

The following charges have been incurred against the contract during the period March 1 to March 31, 1983 .

	Expended	Encumbered
Personal Services (PS)	5,387.06	-0-
Materials and Supplies	761.54	4,098.19
Computer	-0-	-0-
Benefits (@ 21% of PS)	741.70	-0-
Travel	-0-	-0-
Overhead (@ 47.2% of Direct Charges)	3,252.22	-0-
Equipment	-0-	-0-
TOTAL	$10,142.52	$4,098.19

The breakdown of personal services is as follows:

	Dollars	Approximate Hours
Principal Research Scientists/Engineers	-0-	-0-
Senior Research Scientists/Engineers	-0-	-0-
Research Scientists II/EngineersII	-0-	-0-
Research Scientists I/Engineers I	1,947.40	132
Technicians/Draftsmen	1,030.67	99
Students	2,394.63	278
Secretarial/Clerical/Other	14.36	2
TOTAL	$5,387.06	511

The current financial status the contract is as follows:

	Budget as proposed	Expended	Encumbered*	Free Balance
Personal Services (PS)	36,110.00	10,263.48	-0-	25,846.52
Materials & Supplies	10,422.00	1,864.40	26,136.79	(17,579.19)
Computer	-0-	-0-	-0-	-0-
Benefits	7,583.00	1,386.48	-0-	6,196.52
Travel & Shipping	587.89	-0-	-0-	587.89
Overhead	25,821.11	6,378.77	-0-	19,442.34
Equipment	-0-	-0-	-0-	-0-
TOTAL	$80,524.00	$19,893.13	$26,136.79	34,494.08

*47.2% overhead on all direct charge encumbrances.

Based on present partial funding, approximately 57% of the proposed task has been completed.

A-3434

Monthly Technical Report No. 5

and

Monthly Cost and Performance Report No. 5

Report Period
March 25 through April 25, 1983

Report Prepared
May 17, 1983

DEVELOPMENT OF AN 85.5 GHz DUAL POLARIZATION RADIOMETER

J.J. McSheehy

Contract N00014-82-C-2009
EES Project A-3434

Effective Date: 11/26/82
Expiration Date: 11/25/83

Prepared for

Naval Research Laboratory
Washington, D.C. 20375

Prepared by

Engineering Experiment Station
Georgia Institute of Technology
Atlanta, Georgia 30332

WORK PERFORMED DURING THIS PERIOD

The orthomode transducer was polished, gold plated, and mated with the antenna and mixer assembly. Assembly of the control unit is underway and circuit boards for the power supplies, temperature monitor amplifiers, and calibration controller have been completed.

PROBLEMS ENCOUNTERED DURING THIS PERIOD

No problems were encountered during this period.

WORK TO BE PERFORMED DURING THE NEXT PERIOD

The RF front end components have all been delivered and completed with the exception of the isolators. TRG should deliver these in the last week of May. Performance tests of the antenna and front end will be started when these parts arrive. The antenna tests will be done on a roof-top range using a modulated impatt oscillator as a signal source.

Noise figure tests of the front end assembly will be performed using standard hot/cold reference sources in an automatic measurement set-up. The system samples the detected output of the receiver and calculates the Y-factor, system temperature, noise figure and/or the impedance mismatch between the mixer and IF amplifier.

Most mechanical components of the RF box are still being fabricated, but these should be complete by the end of June. Assembly of this section will begin when major components (chopper housing, baseplate, etc.) are complete.

Project Number A-3434

Cost Information

The following charges have been incurred against the contract during the period April 1 to April 30, 1983.

	Expended	Encumbered
Personal Services (PS)	4,173.71	-0-
Materials and Supplies	19,080.80	(16,766.77)
Computer	-0-	-0-
Benefits (@ 21% of PS)	852.18	-0-
Travel	288.40	-0-
Overhead (@ 47.2% of Direct Charges)	11,514.48	-0-
Equipment	-0-	-0-
TOTAL	$35,909.57	($16,766.77)

The breakdown of personal services is as follows:

	Dollars	Approximate Hours
Principal Research Scientists/Engineers	-0-	-0-
Senior Research Scientists/Engineers	-0-	-0-
Research Scientists II/Engineers II	-0-	-0-
Research Scientists I/Engineers I	2,496.66	170
Technicians/Draftsmen	1,052.90	101
Students	583.20	68
Secretarial/Clerical/Other	40.95	5
TOTAL	$4,173.71	344

The current financial status of the contract is as follows:

	Budget as Proposed	Expended	Encumbered*	Free Balance
Personal Services (PS)	36,110.00	14,437.19	-0-	21,672.81
Materials & Supplies	10,422.00	20,945.20	9,370.02	(19,893.22)
Computer	-0-	-0-	-0-	-0-
Benefits	7,583.00	2,238.66	-0-	5,344.34
Travel & Shipping	587.89	288.40	-0-	299.49
Overhead	25,821.11	17,893.25	-0-	7,927.86
Equipment	-0-	-0-	-0-	-0-
TOTAL	$80,524.00	$55,802.70	$9,370.00	$15,351.28

*47.2% overhead on all direct charge encumbrances.

Based on present partial funding, approximately 81% of the proposed task has been completed.

A-3434

Monthly Technical Report No. 6

and

Monthly Cost and Performance Report No. 6

Report Period
April 25 through May 25, 1983

Report Prepared
July 6, 1983

DEVELOPMENT OF AN 85.5 GHz DUAL POLARIZATION RADIOMETER

J.J. McSheehy

Contract N00014-82-C-2009
EES Project A-3434

Effective Date: 11/26/82
Expiration Date: 11/25/83

Prepared for

Naval Research Laboratory
Washington, D.C. 20375

Prepared by

Engineering Experiment Station
Georgia Institute of Technology
Atlanta, Georgia 30332

WORK PERFORMED DURING THIS PERIOD

The outer enclosure (white box) was received and the front and rear panels are being modified to accept connectors and the antenna window. The rubber gaskets were removed and replaced with dual RF gaskets which will provide both environmental and RFI protection.

Major components of the receiver such as the Dicke chopper and RF baseplate are being fabricated by the machine shop. The control unit and associated circuits are being assembled.

PROBLEMS ENCOUNTERED DURING THIS PERIOD

Several problems occurred during this report period. The isolators were finally delivered by Alpha/TRG, but were three inches longer than the catalog specification for length. This necessitated a major re-design of the RF baseplate and waveguide runs. A corrosion problem developed on the interior walls of the horn antenna because of trapped fluids and a porous gold plate finish. The vendor has agreed to repair the horn at no charge, but this has caused a delay in testing of the antenna pattern, orthomode transducer, and overall front end performance.

WORK TO BE PERFORMED NEXT PERIOD

Assembly and testing will continue with major emphasis on completion of the control unit. Testing of the RF front end will resume pending completion of the new waveguide sections and repair of the antenna.

Project Number A-3434

COST INFORMATION

The following charges have been incurred against the contract during the period May 1 - May 31, 1983 .

	Expended	Encumbered
Personal Services (PS)	4,080.95	-0-
Materials and Supplies	4,682.89	(3,649.87)
Computer	-0-	-0-
Benefits (@ 21% of PS)	776.04	-0-
Travel	-0-	-0-
Overhead (@ 47.2% of Direct Charges)	4,502.82	-0-
Equipment	-0-	-0-
TOTAL	$14,042.70	($3,649.87)

The breakdown of personal services is as follows:

	Dollars	Approximate Hours
Principal Research Scientists/Engineers	-0-	-0-
Senior Research Scientists/Engineers	-0-	-0-
Research Scientists II/Engineers II	-0-	-0-
Research Scientists I/Engineers I	2,995.99	204
Technicians/Draftsmen	221.07	21
Students	686.37	80
Secretarial/Clerical/Other	177.52	22
TOTAL	$4,080.95	327

The current financial status of the contract is as follows:

	Budget as Proposed	Expended	Encumbered*	Free Balance
Personal Services (PS)	$36,110.00	18,518.14	-0-	17,591.86
Materials & Supplies	10,422.00	25,628.09	5,720.15	(20,926.24)
Computer	-0-	-0-	-0-	-0-
Benefits	7,583.00	3,014.70	-0-	4,568.30
Travel & Shipping	587.89	288.40	-0-	299.49
Overhead	25,821.11	22,396.07	-0-	3,425.04
Equipment	-0-	-0-	-0-	-0-
TOTAL	$80,524.00	$69,845.40	$5,720.15	$4,958.45

*47.2% overhead on all direct charge encumbrances.

Based on present partial funding, approximately 94 % of the proposed task has been completed.

Monthly Technical Report No. 7

and

Monthly Cost and Performance Report No. 7

Report Period
May 25 through June 25, 1983

Report Prepared
August 12, 1983

DEVELOPMENT OF AN 85.5 GHz DUAL POLARIZATION RADIOMETER

J.J. McSheehy

Contract N00014-82-C-2009
EES Project A-3434

Effective Date: 11/26/82
Expiration Date: 11/25/83

Prepared for

Naval Research Laboratory
Washington, D.C. 20375

Prepared by

Engineering Experiment Station
Georgia Institute of Technology
Atlanta, Georgia 30332

WORK PERFORMED DURING THIS PERIOD

The control unit is being assembled and the various control circuits are being checked out. Figure 1 shows the front and rear panels of the control unit and the arrangement of controls. Calibration sequencing will be performed by a single-board computer programmed in Tiny Basic. The computer reads the front panel "Calibration Interval" and "Reference Dwell" Thumbwheel switches and converts these inputs to command signals at the required intervals. If an impossible command is entered (i.e.: calibration interval less than the total dwell time for both loads), the computer will flash all three calibration state LED's and recheck the switches until a correct set of inputs are entered. The other controls are similar to the Georgia Tech 140/220 GHz control unit and are self explanatory.

Figure 2 shows the horn antenna, orthomode transducer, and dual channel receiver assembled for testing. The antenna was returned to us in early August and has been replated internally. Pattern measurements will be performed when test equipment becomes available (mid-August).

The Dicke chopper assembly is shown in Figure 3. The rear view shows the solenoid used to lock the chopper blade in an open position when the radiometer is switched to the Total Power mode. The control circuit for the solenoid includes several redundant interlocks to prevent its operation while the chopper motor is running. A delay of about thirty seconds is required when switching from Dicke to Total Power mode to allow the blade to spin down and stop before the solenoid can be activated.

Modifications of the outer "white box" have been completed and the RF shielded inner enclosure has been fabricated as shown in Figure 4. A combination of double gaskets on the inner enclosure along with shielded input connectors should minimize RFI pickup in the 100-1000 MHz IF band. The inner enclosure is mounted on polyethylene rails and is electrically isolated from the outer enclosure.

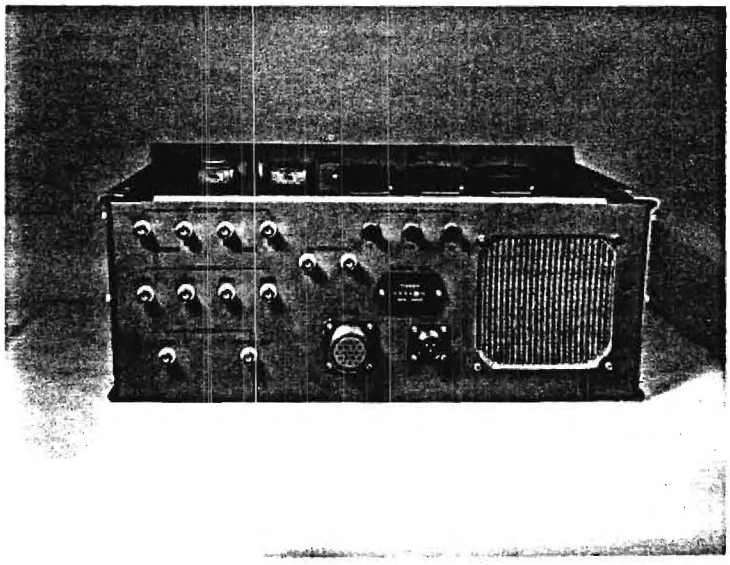

Figure 1. Control Unit

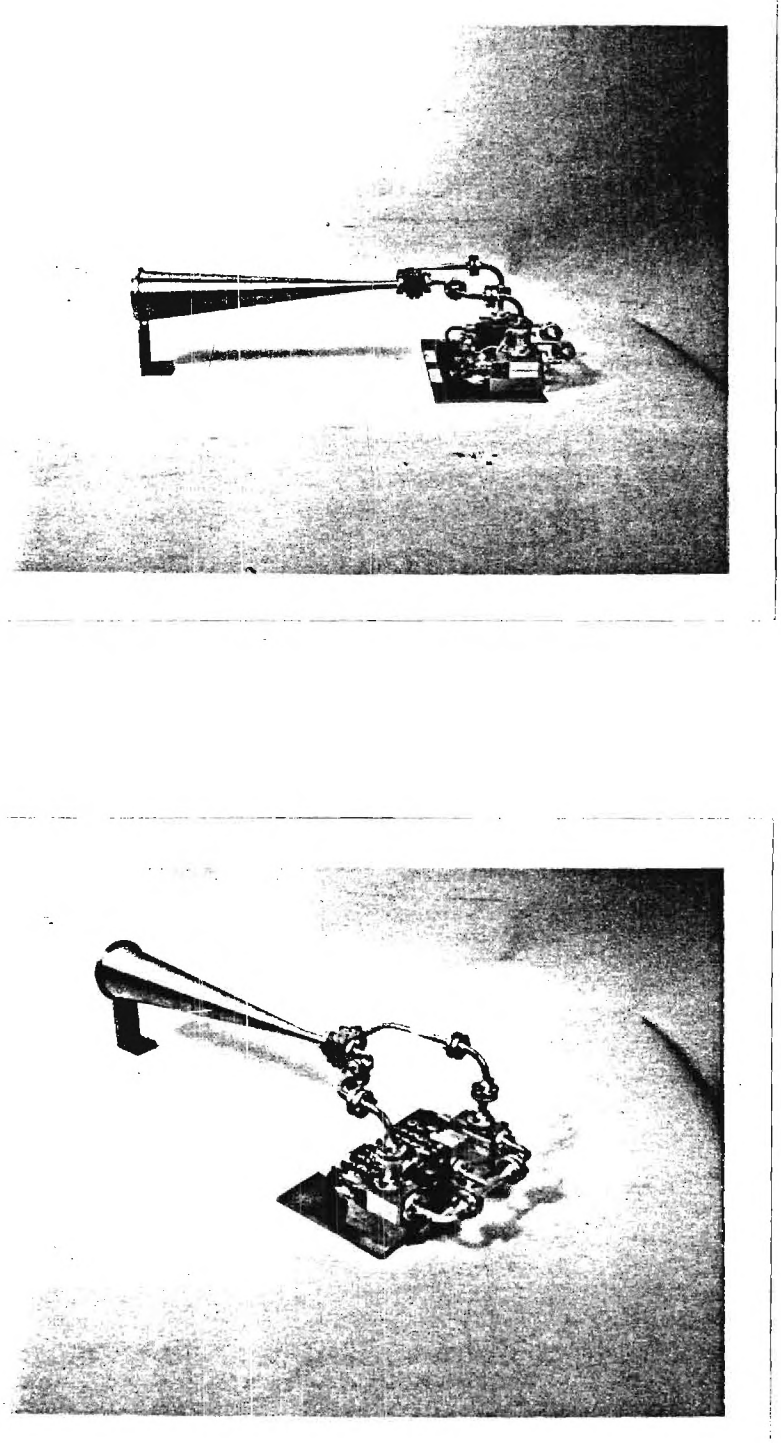

Figure 2. Antenna/Front End Assembly

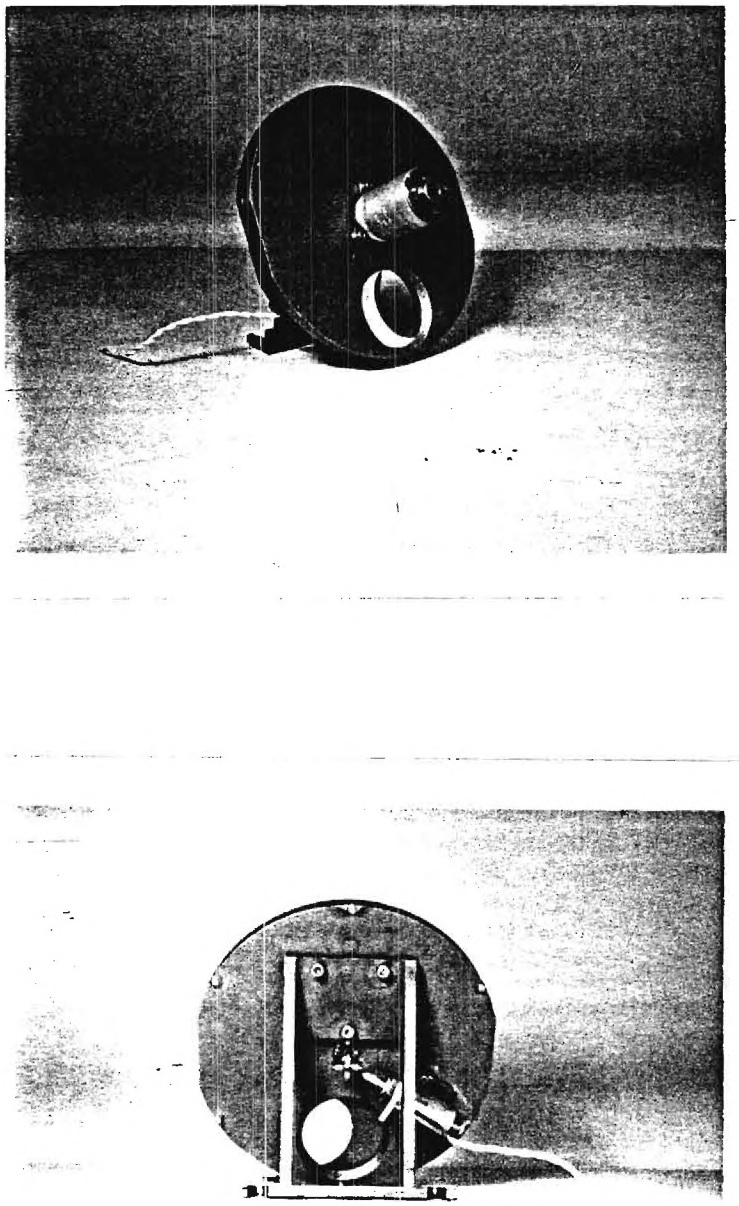

Figure 3. Dicke Chopper Assembly

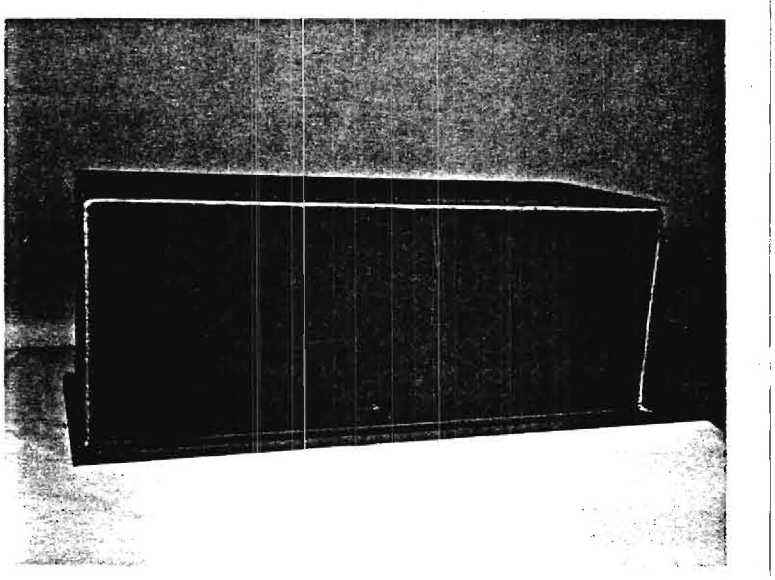

Figure 4. RF Shielded Inner Enclosure

PROBLEMS ENCOUNTERED DURING THIS PERIOD

The horn antenna was received and appeared to be in good condition. After several days, some corrosion again was visible. The vendor has agreed to replace the horn, but this would result in an additional four to six week delay. Since the problem is minor compared with the original corrosion, we have decided to accept the horn to avoid further delays and circumvent the problem in another way. The remaining corrosion is cosmetic and should cause no changes in the performance of the horn. To prevent any possibility of particles entering the mixers, a quarter-mil mylar window will be inserted at the flange between the horn and orthomode transducer. The window will block any loose particles and should have no measurable effect on system performance.

WORK TO BE PERFORMED NEXT PERIOD

The control unit will be completed and integrated with the RF package. System testing will begin as soon as possible.

Project Number A-3434

COST INFORMATION

The following charges have been incurred against the contract during the period June 1 - June 30, 1983.

	Expended	Encumbered
Personal Services (PS)	4,247.12	-0-
Materials and Supplies	4,048.98	(2,931.03)
Computer	-0-	-0-
Benefits (@21%of PS)	457.93	-0-
Travel	-0-	-0-
Overhead (@47.2% of Direct Charges)	4,131.90	-0-
Equipment	-0-	-0-
TOTAL	$12,885.93	(2,931.03)

The breakdown of personal services is as follows:

	Dollars	Approximate Hours
Principal Research Scientists/Engineers	-0-	-0-
Senior Research Scientists/Engineers	-0-	-0-
Research Scientists II/Engineers II	-0-	-0-
Research Scientists I/Engineers I	1,348.20	92
Technicians/Draftsmen	596.88	57
Students	2,115.65	245
Secretarial/Clerical/Other	186.39	23
TOTAL	$4,247.12	417

The current financial status of the contract is as follows:

	Budget as Proposed	Expended	Encumbered*	Free Balance
Personal Services (PS)	$46,912.00	22,765.26	-0-	24,146.74
Materials & Supplies	30,119.00	29,677.07	2,789.12	(2,347.19)
Computer	-0-	-0-	-0-	-0-
Benefits	9,852.00	3,472.63	-0-	6,379.37
Travel & Shipping	1,787.89	288.40	-0-	1,499.49
Overhead	41,853.11	26,527.97	-0-	15,325.14
Equipment	-0-	-0-	-0-	-0-
TOTAL	$130,524.00	$82,731.33	$2,789.12	$45,003.55

*47.2% overhead on all direct charge encumbrances.

Based on present funding, approximately 63% of the proposed task has been completed.

A-3434

Monthly Technical Report No. 8
and
Monthly Cost and Performance Report No. 8

Report Period
June 25 through July 25, 1983

Report Prepared
August 24, 1983

DEVELOPMENT OF AN 85.5 GHz DUAL POLARIZATION RADIOMETER

J. J. McSheehy

Contract N00014-82-C-2009
EES Project A-3434

Effective Date: 11/26/82
Expiration Date: 11/25/83

Prepared for
Naval Research Laboratory
Washington, D.C. 20375

Prepared by

Engineering Experiment Station
Georgia Institute of Technology
Atlanta, Georgia 30332

Work Performed During This Period

All machine shop work has been completed and the component layout for the RF package has been finalized. Assembly and testing of the control unit and RF package were proceding.

Problems Encountered During This Period

The following problems currently face this program:

1. Project funding based on FY83 rates for pay, fringe benefits, and overhead is insufficient to complete the remaining work because of increases in these rates for FY84, and additional, unplanned, materials and supplies expenses. The program schedule will overlap into FY84 more than originally planned because of initial funding delays and a major redesign effort involving the isolator/waveguide layout on the RF baseplate. Additional materials and supplies expenses were incurred because of price increases between submission of the proposal and placing orders, and because an isolator ($1385.00) was needed to stabilize the Gunn oscillator output. The overlap into FY84, combined with increased FY84 rates and materials expenses will cause remaining funds to be depleted before the remaining work can be completed.

2. The schedule of work has slipped by six to eight weeks from what was proposed. Again, this is due to the isolator/waveguide redesign effort and a manpower shortage in the machine shop and laboratory that has prevented parallel work on some portions of the radiometer.

Because of the above, I am requesting that the Georgia Tech Office of Contract Administration initiate a contract modification request to extend the contract end date from 11/25/83 to 1/25/84 and increase the total funding from $130,524 to $153,813. Tables 1 through 4 provide a breakdown of the additional expenses.

Work to be Performed During the Next Period

Work on the RF package and control unit will continue. RFI/EMI tests will be performed to find and correct any interference problems in the IF and analog circuits. Particular attention will be given to the 1000 to 1250 MHz TACAN/IFF band.

Table 1

Additional Materials and Supplies Expense

Item	Cost as Proposed	Actual Cost
Antenna Isolators	$2,200.00	$2,700.00
Chopper Motor and Controller	560.00	653.00
Calibration Stepper Motor	100.00	186.00
Rack Cabinet	150.00	349.00
Gunn Isolator	-0-	1,385.00
Total Cost	$3,010.00	$5,273.00

Actual Cost	$5,273.00
Cost as Proposed	3,010.00
Total Additional Cost	$2,263.00
Overhead @ 47%	1,064.00
Total Additional Materials and Supplies Expense	$3,327.00

Table 2

Additional Expense Due to Isolator/Waveguide Redesign and Schedule Slippage

Personnel Services	
2 weeks Machinist	$ 930.00
2 weeks Draftsman	930.00
8 weeks Research Engineer I	5,254.00
Total Personnel Services	$7,114.00
Fringe Benefits @ 23.5%	$1,672.00
Materials and Supplies	
Waveguide Flanges	65.00
WR-12 Waveguide	48.00
Total Direct Charges	$8,899.00
Overhead @ 49.4%	4,396.00
Total Additional Expense for Isolator/Waveguide Redesign and Schedule Slippage	$13,295.00

Table 3

Additional Expense Due to Fiscal Year Overlap

The following changes occurred on 7/1/83:

1) Wages increased an average of 10%
2) The fringe benefit rate increased from 21 to 23.5%
3) The overhead rate increased from 47 to 49.4%

Item	As Proposed (FY83)	Actual (FY84)
Remaining Personnel Services 7/1/83	$24,147.00	$26,562.00
Remaining Fringe Benefits	5,071.00	6,242.00
Remaining Travel & Shipping	1,450.00	1,450.00
Remaining Materials and Supplies	5,135.00	5,135.00
Total Direct Charges	$35,803.00	$39,839.00
Overhead on Total Direct Charges	16,827.00	19,458.00
Total	$52,630.00	$59,297.00

Total Actual Expense	$59,297.00
Total Expense as Proposed	52,630.00
Total Additional Expense Due to Fiscal Year Overlap	$ 6,667.00

Table 4

Summary of Additional Expense
Incurred on Contract N00014-82-C-2009

Materials and Supplies	$ 3,327.00
Isolator/Waveguide Redesign	13,295.00
Fiscal Year Rate Increases	6,667.00
Total Contract Additional Expense	$23,289.00

Project Number A-3434

Cost Information

The following charges have been incurred against the contract during the period July 1 - July 31, 1983

	Expended	Encumbered
Personal Services (PS)	$ 5,564.08	-0-
Materials and Supplies	1,197.23	($3,937.85)
Computer	-0-	-0-
Benefits (@23.5% of PS)	996.21	-0-
Travel	-0-	-0-
Overhead (@49.4% of Direct Charges)	3,882.21	-0-
Equipment	-0-	-0-
TOTAL	$11,589.73	($3,937.85)

The breakdown of personal services is as follows:

	Dollars	Approximate Hours
Principal Research Scientists/Engineers	-0-	-0-
Senior Research Scientists/Engineers	510.94	20
Research Scientists II/Engineers II	-0-	-0-
Research Scientists I/Engineers I	2,501.90	152
Technicians/Draftsmen	1,076.96	104
Students	1,379.35	192
Secretarial/Clerical/Other	95.03	11
TOTAL	$5,564.08	479

The current financial status of the contract is as follows:

	Budget as Proposed	Expended	Encumbered*	Free Balance
Personal Services (PS)	$46,912.00	$28,329.34	-0-	$18,582.66
Materials & Supplies	30,119.00	30,874.30	3,937.85	(4,693.15)
Computer	-0-	-0-	-0-	-0-
Benefits	9,852.00	4,468.84	-0-	5,383.16
Travel & Shipping	1,787.89	288.40	-0-	1,499.49
Overhead	41,853.11	30,360.18	-0-	11,492.93
Equipment	-0-	-0-	-0-	-0-
TOTAL	$130,524.00	$94,321.06	$3,937.85	$32,265.09

*49.4% overhead on all direct charge encumbrances.

Based on present funding, approximately 75 % of the proposed task has been completed.

A-3434

Monthly Technical Report No. 9
and
Monthly Cost and Performance Report No. 9

Report Period
July 25 through August 25, 1983

Report Prepared
October 3, 1983

DEVELOPMENT OF AN 85.5 GHz DUAL POLARIZATION RADIOMETER

J. J. McSheehy

Contract N00014-82-C-2009
EES Project A-3434

Effective Date: 11/26/82
Expiration Date: 11/25/83

Prepared for
Naval Research Laboratory
Washington, D. C. 20375

Prepared by
Engineering Experiment Station
Georgia Institute of Technology
Atlanta, Georgia 30332

WORK PERFORMED DURING THIS PERIOD

Assembly and testing of the radiometer and control unit are continuing.

PROBLEMS ENCOUNTERED DURING THIS PERIOD

The remaining funds and time are insufficient to complete all remaining tasks as outlined in progress letter number 8. Work on this program will continue only as long as funds are available.

WORK TO BE PERFORMED DURING THE NEXT PERIOD

A contract modification request in the form of an unsolicited proposal will be submitted to the NRL contracting officer for the purpose of correcting the present unsatisfactory schedule and funding situation. Assembly, testing, and documentation for the radiometer system will continue.

James McSheehy, the current project director, is resigning his position with Georgia Tech effective October 17, 1983. Joseph A. Gagliano has been appointed as the new project director.

Project Number A-3434

Cost Information

The following charges have been incurred against the contract during the period August 1 through August 31, 1983

	Expended	Encumbered
Personal Services (PS)	$ 6,880.31	-0-
Materials and Supplies	2,597.73	(1,970.00)
Computer	-0-	-0-
Benefits (@23.5% of PS)	875.39	-0-
Travel	-0-	-0-
Overhead (@49.4% of Direct Charges)	5,114.59	-0-
Equipment	-0-	-0-
TOTAL	$15,468.02	(1,970.00)

The breakdown of personal services is as follows:

	Dollars	Approximate Hours
Principal Research Scientists/Engineers	-0-	-0-
Senior Research Scientists/Engineers	-0-	-0-
Research Scientists II/Engineers II	-0-	-0-
Research Scientists I/Engineers I	1,781.91	109
Technicians/Draftsmen	3,095.55	266
Students	2,981.55	306
Secretarial/Clerical/Other	231.52	27
TOTAL	$6,880.31	708

The current financial status of the contract is as follows:

	Budget as Proposed	Expended	Encumbered*	Free Balance
Personal Services (PS)	$46,912.00	$35,209.65	-0-	$11,702.35
Materials & Supplies	30,119.00	33,472.03	1,967.85	(5,320.88)
Computer	-0-	-0-	-0-	-0-
Benefits	9,852.00	5,344.23	-0-	4,507.77
Travel & Shipping	1,787.89	288.40	-0-	1,499.49
Overhead	41,853.11	35,474.77	-0-	6,378.34
Equipment	-0-	-0-	-0-	-0-
TOTAL	$130,524.00	$109,789.08	$1,967.85	$18,767.07

*49.4% overhead on all direct charge encumbrances.

Based on present funding, approximately 86% of available funds have been expended. Remaining funds are not sufficient to complete the proposed task.

Monthly Technical Report No. 10

and

Monthly Cost and Performance Report No. 10

Report Period

September 1 through September 30, 1983

Report Prepared

October 13, 1983

DEVELOPMENT OF AN 85.5 GHz POLARIZATION RADIOMETER

J. A. Gagliano

Contract N00014-82-C-2009

EES Project A-3434

Effective Date: 11/26/82

Expiration Date: 11/25/83

Prepared for

Naval Research Laboratory
Washington, D.C. 20375

Prepared by

Engineering Experiment Station
Georgia Institute of Technology
Atlanta, Georgia 30332

WORK PERFORMED DURING THIS PERIOD

Component testing of the radiometer and the control unit continues. Assembly and wiring of the system is progressing.

PROBLEMS ENCOUNTERED DURING THIS PERIOD

A request for additional time and funds was submitted to the sponsor in the form of a letter proposal (EM-MMD-1404). The remaining funds and time are insufficient to complete the remaining technical efforts and the work on this program will continue only as long as funds are available.

WORK TO BE PERFORMED DURING THE NEXT PERIOD

Assembly and wiring of the radiometer and control unit will be completed. Testing of the system will begin and preliminary documentation (schematics and wiring diagrams) will continue.

Project Number A-3434

Cost Information

The following charges have been incurred against the contract during the period September 1 through September 30, 1983:

	Expended	Encumbered
Personal Services (PS)	$2,992.31	-0-
Materials & Supplies	506.81	(160.27)
Computer	-0-	-0-
Benefits (@ 23.5% of PS)	363.67	-0-
Travel	-0-	-0-
Overhead (@ 49.4% of Direct Charges)	1,908.22	-0-
Equipment	-0-	-0-
TOTAL	$5,771.01	(160.27)

The breakdown of personal services is as follows:

	Dollars	Approximate Hours
Principal Research Scientists/Engineers	-0-	-0-
Senior Research Scientists/Engineers	-0-	-0-
Res. Scientists II/Engineers II	-0-	-0-
Res. Scientists I/Engineers I	920.09	56
Technicians/Draftsmen	560.51	54
Students	$1,444.80	202
Secretarial/Clerical/Other	66.91	8
TOTAL	$2,992.31	320

The current financial status of the contract is as follows:

	Budget as Proposed	Expended	Encumbered*	Free Balance
Personal Services (PS)	$46,912.00	$38,201.96	-0-	$8,710.04
Materials & Supplies	30,119.00	33,978.84	$1,807.58	(5,667.42)
Computer	-0-	-0-		-0-
Benefits	9,852.00	5,707.90	-0-	4,144.10
Travel & Shipping	1,787.89	288.40	-0-	1,499.49
Overhead	41,853.11	37,382.99	-0-	4,470.12
Equipment	-0-	-0-	-0-	-0-
TOTAL	$130,524.00	$115,560.09	$1,807.58	$13,156.33

*49.4% overhead on all direct charge encumbrances.

Based on present fundings, approximately 90% of available funds have been expended. Remaining funds are not sufficient to complete the proposed task.

A-3434

Monthly Technical Report No. 11

and

Monthly Cost and Performance Report No. 11

Report Period

October 1 through October 31, 1983

Report Prepared

November 14, 1983

DEVELOPMENT OF AN 85.5 GH_z POLARIZATION RADIOMETER

J. A. Gagliano

Contract N00014-82-C-2009

EES Project A-3434

Effective Date : 11/26/82
Expiration Date: 11/25/83

Prepared for

Naval Research Laboratory
Washington, D.C. 20375

Prepared by

Engineering Experiment Station
Georgia Institute of Technology
Atlanta, Georgia 30332

WORK PERFORMED DURING THIS PERIOD

Component testing of the radiometer continues. Assembly and wiring of the radiometer is 90% complete. The control panel testing is progressing.

PROBLEMS ENCOUNTERED DURING THIS PERIOD

As was reported in the previous progress report, a request for additional time and funds was submitted to the sponsor in the form of a letter proposal (EM-MMD-1404). The remaining funds and time are insufficient to complete the remaining technical efforts and the work on this program will continue only as long as funds are available.

WORK TO BE PERFORMED DURING THE NEXT PERIOD

Testing of the radiometer's control panel will be completed. The radiometer assembly will be completed and the system (control panel plus radiometer) testing will continue as long as funds remain on the contract.

Project Number A-343[illegible]

[illegible]

The following cha[illegible] against the contract during the period Octo[illegible] 31, 1983:

	Billed	Encumbered
Personal Services (PS[illegible]	$[illegible]0.89	-0-
Materials & Supplies	47[illegible].68	(183.85)
Computer	-	-0-
Benefits (@ 23.5% of P[illegible]	[illegible]03.03	-0-
Travel	-0-	-0-
Overhead (@49.4% of Di[illegible] Charges)	3,0[illegible].66	-0-
Equipment	-0-	-0-
TOTAL	$9[illegible].25	(183.85)

The breakdown of perso[illegible] services is as follows:

	Dollars	Approximate Hours
Principal Research Sci[illegible]ist/Engineers	-0-	-0-
Senior Research Scient[illegible]s/Engineers	$1,966.68	77
Res. Scientists II/Eng[illegible]ers II	-0-	-0-
Res. Scientists I / En[illegible]eers I	1,533.48	93
Technicians/Draftsmen	5.72	1
Students	1,269.90	177
Secretarial/Clerical/O[illegible]	175.10	20
TOTAL	4,950.88	368

The current financial status of the contract is as follows:

Budget As	Proposed	Expended	Encumbered*	Free Balance
Personal Services (PS)	$ 46,912.00	$43,152.84	-0-	$ 3,759.16
Materials & Supplies	30,119.00	34,435.52	$1,623.73	(5,940.25)
Computer	-0-	-0-		-0-
Benefits	9,852.00	6,572.93	-0-	3,279.07
Travel & Shipping	1,787.89	288.40	-0-	1,499.49
Overhead	41,853.11	40,481.65	-0-	1,371.46
Equipment	-0-	-0-	-0-	-0-
TOTAL	$130,524.00	$124,931.34	$1,623.73	$ 3,968.93

*49.4% overhead on all direct charge encumbrances.

Based on present fundings, approximately 97% of available funds have been expended. Remaining funds are not sufficient to complete the proposed task.

A-3434

Monthly Technical Report No. 12
and
Monthly Cost and Performance Report No. 12

Report Period
November 1 through November 30, 1983

Report Prepared
December 20, 1983

DEVELOPMENT OF AN 85.5 GHz POLARIZATION RADIOMETER

J. A. Gagliano

Contract N00014-82-C-2009
EES Project A-3434

Effective Date: 11/26/82
Expiration Date: 2/25/84

Prepared for
Naval Research Laboratory
Washington, D. C. 20375

Prepared by

Engineering Experiment Station
Georgia Institute of Technology
Atlanta, Georgia 30332

Work Performed During This Period

The control panel testing was completed. This included the subsystem electronics such as the phase sensitive detector (dual channel), the temperature controller, the calibration interface board, and other miscellaneous circuits.

The radiometer assembly and wiring was completed during this period. All power, control and signal cabling in the radiometer is complete with the exception of the semi-rigid cabling in the IF section.

Problems Encountered During This Period

The funds allocated to this program, with the exception of shipping costs, have been expended as of the end of this reporting period. The no-cost extension of the program until 25 February 1984 is currently in effect. Remaining funds are not sufficient to complete the total technical effort originally proposed.

Work to be Performed During the Next Period

The rough draft documentation will be formulated and become a part of the deliverable 85.5 GHz radiometer and control panel assembly. Due to a lack of funds it is unlikely that the radiometer will be fully tested. A status report of the radiometer will be included in the next progress report.

Project Number A-3434

COST INFORMATION

The following charges have been incurred against the contract during the period Nov. 1 through Nov. 30, 1983.

	Expended	Encumbered
Personal Services (PS)	$1,209.04	-0-
Materials and Supplies	1,499.62	(1,385.00)
Computer	-0-	-0-
Benefits (23.5% of PS)	170.47	-0-
Travel	-0-	-0-
Overhead (@ 49.4% of Direct Charges)	1,422.29	-0-
Equipment	-0-	-0-
TOTAL	$4,301.42	($1,385.00)

The breakdown of personal services is as follows:

	Dollars	Approximate Hours
Principal Research Scientists/Engineers	-0-	-0-
Senior Research Scientists/Engineers	$ 425.70	17
Research Scientists II/Engineers II	-0-	-0-
Research Scientists I/Engineers I	-0-	-0-
Technicians/Draftsmen	110.57	10
Students	641.35	89
Secretarial/Clerical/Other	31.42	4
TOTAL	$1,209.04	120

The current financial status of the contract is as follows:

	Budget as Proposed	Expended	Encumbered*	Free Balance
Personal Services (PS)	$46,912.00	$44,361.88	-0-	$2,550.12
Materials & Supplies	30,119.00	35,935.14	238.73	(6,054.87)
Computer	-0-	-0-	-0-	-0-
Benefits	9,852.00	6,743.40	-0-	3,108.60
Travel & Shipping	1,787.89	288.40	-0-	1,499.49
Overhead	41,853.11	41,903.94	-0-	(50.83)
Equipment	-0-	-0-	-0-	-0-
TOTAL	$130,524.00	$129,232.76	238.73	$1,052.51

*49.4% overhead on all direct charge encumbrances.

Based on present fundings, approximately 99% of available funds have been expended. Remaining funds are not sufficient to complete the proposed task.

A-3434

Monthly Technical Report No. 13
and
Monthly Cost and Performance Report No. 13

Report Period
December 1 through December 31, 1983

Report Prepared
January 10, 1984

DEVELOPMENT OF AN 85.5 GHz POLARIZATION RADIOMETER

J. A. Gagliano

Contract N00014-82-C-2009
EES Project A-3434

Effective Date: 11/26/82
Expiration Date: 2/25/84

Prepared for
Naval Research Laboratory
Washington, D. C. 20375

Prepared by
Engineering Experiment Station
Georgia Institute of Technology
Atlanta, Georgia 30332

Work Performed During This Period

The radiometer/control panel system was connected and power was applied. The temperature control circuits for the hot calibration load, radiometer baseplate, and cold calibration load were adjusted and checked out.

Problems Encountered During This Period

The technical effort has been reduced significantly due to lack of funds. Remaining funds are not sufficient to complete the total proposed technical effort.

Work to be Performed During the Next Period

Testing of the system will continue at a reduced level. The status report on the radiometer will be delayed until the final progress report (next period).

Project Number A-3434

COST INFORMATION

The following charges have been incurred against the contract during the period Dec. 1 through Dec. 31, 1983

	Expended	Encumbered
Personal Services (PS)	$470.85	-0-
Materials and Supplies	6.92	(70.58)
Computer	-0-	-0-
Benefits (23.5% of PS)	29.19	-0-
Travel	-0-	-0-
Overhead (@49.4% of Direct Charges)	250.44	-0-
Equipment	-0-	-0-
TOTAL	$757.40	(70.58)

The breakdown of personal services is as follows:

	Dollars	Approximate Hours
Principal Research Scientists/Engineers	0	-0-
Senior Research Scientists/Engineers	0	0
Research Scientists II/Engineers II	0	0
Research Scientists I/Engineers I	0	0
Technicians/Draftsmen	0	0
Students	431.60	60
Secretarial/Clerical/Other	39.25	5
TOTAL	$470.85	65

The current financial status of the contract is as follows:

	Budget as Proposed	Expended	Encumbered*	Free Balance
Personal Services (PS)	$46,912.00	$44,832.73	$ -0-	$2,079.27
Materials & Supplies	30,119.00	35,942.06	168.15	(5,991.21)
Computer	-0-	-0-	-0-	-0-
Benefits	9,852.00	6,772.59	-0-	3,079.41
Travel & Shipping	1,787.89	288.40	-0-	1,499.49
Overhead	41,853.11	42,154.38	-0-	(301.27)
Equipment	-0-	-0-	-0-	-0-
TOTAL	$130,524.00	$129,990.16	168.15	$ 365.69

Based on present fundings, approximately 99% of available funds have been expended. Remaining funds are not sufficient to complete the proposed task. Total free balance will be used for shipping charges.

A-3434

85.5 GHz DUAL POLARIZATION RADIOMETER

Prepared by

GEORGIA INSTITUTE OF TECHNOLOGY
A Unit of the University System of Georgia
Engineering Experiment Station
Atlanta, Georgia 30332

February 1984

OPERATION/MAINTENANCE MANUAL

Prepared for

NAVAL RESEARCH LABORATORY
WASHINGTON, D. C. 20375

Contract No. N00014-83-C-2009

Operation/Maintenance Manual

85.5 GHz Dual Polarization Radiometer

J. A. Gagliano

February 1984

Contract No. N00014-83-C-2009

Georgia Tech Project No. A-3434

For

Naval Research Laboratory
Washington, D. C. 20375

Georgia Institute of Technology
Engineering Experiment Station
Atlanta, Georgia 30332

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

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	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): J.A. Gagliano	8. CONTRACT OR GRANT NUMBER(s): N00014-83-C-2009
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18. SUPPLEMENTARY NOTES

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20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

A 85.5 GHz radiometer was designed, constructed, and delivered to NRL as part of the Special Sensor Microwave Imager (SSM/I) simulator to be used onboard NRL's RP3-A aircraft. The radiometer has dual polarization, self-calibration, and temperature control operation from a remote control unit.

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SUMMARY

This report documents the operation and maintenance of a 85.5 GHz dual polarization, Total Power/Dicke radiometer to be used as part of the SSM/I simulator system onboard a P-3 aircraft. The 85.5 GHz radiometer uses an all solid state, low noise, broadband, room temperature receiver with specifications that match the desired satellite instrument to be used on the future Defense Meteorological Satellite Program (DMSP). Remote switching between Total Power and Dicke operation is provided. Horizontal and vertical polarization data is provided simultaneously. Radiometer temperature control and self-calibration is provided through the use of the Georgia Tech designed remote control unit.

PREFACE

This report was prepared by the Electromagnetics Laboratory of the Engineering Experiment Station, Georgia Institute of Technology under NRL contract N00014-83-C-2009. The contract technical monitor was Dr. Jim Hollinger. The contract period was from November 1982 to February 1984. This document describes the operation and maintenance of the 85.5 GHz dual polarization radiometer.

The author of this report was Mr. J. A. Gagliano. The views and conclusions in this document are those of the author and should not be interpreted as necessarily representing the official policies of the Naval Research Laboratory or the U.S. Government.

The author would like to acknowledge the contributions made by the following Georgia Tech personnel: R. E. Forsythe, D. M. Guillory, R. H. Platt, and D. O. Gallentine.

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1.0 Introduction

The purpose of this program was to develop an aircraft version of the 85.5 GHz radiometer to be used as part of the SSM/I simulator on the NRL RP3-A aircraft. The Special Sensor Microwave Imager (SSM/I) will eventually be flown on the Defense Meteorological Satellite Program (DMSP) and the Georgia Tech developed radiometer will simulate as closely as possible the future satellite sensor.

Figure 1 is a block diagram of the radiometer system consisting of the sensor (RFI subenclosure), the internal calibration and Dicke reference loads with chopper, and the remote control unit. The radiometer front-end (mixer, pre-amplifier, and local oscillator chain) was procured as a sub-assembly with specifications matching the desirable satellite sensor front-end. The radiometer was designed to function in either the Total Power or the Dicke mode (control panel switch selectable). Table 1 is a summary of the system performance specifications for the 85.5 GHz radiometer

The system consists of the antenna, absolute calibration and Dicke reference loads, Dicke high speed mechanical chopper, dual channel down converter with preamp assembly, IF amplifiers and square law detectors. For the Dicke mode, the system uses a rotating fan-blade chopper to quasi-optically switch the antenna between the external scene and the Dicke load. A rotating plate with 45^{o} angled reflectors, mounted in front of the chopper, switches alternately between the hot and cold calibration loads during each calibration cycle.

2.0 85.5 GHz Radiometer Description

2.1 Antenna/RF Subsystem

A high efficiency corrugated conical horn mounted behind the chopper assembly couples received energy into an orthomode transducer. The polarization components are separated in the orthomode transducer and enter the inputs of isolators which

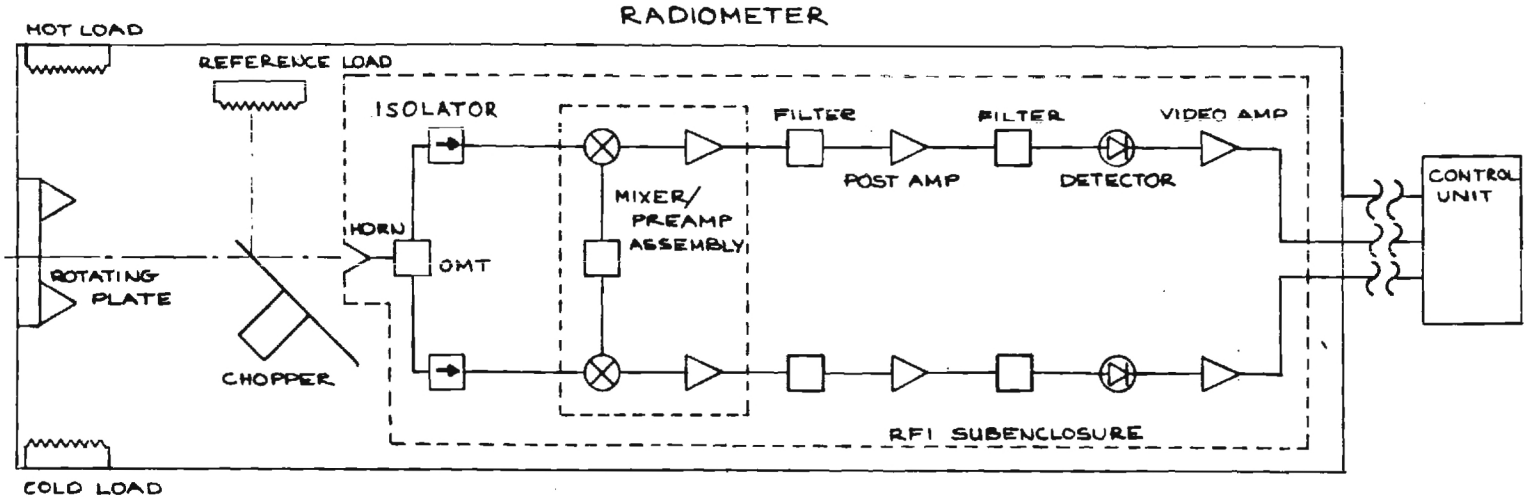

Figure 1. Block Diagram of 85.5 GHz Dual Polarization Radiometer

TABLE 1

PERFORMANCE SPECIFICATIONS SUMMARY

PARAMETER CHARACTERISTICS	PERFORMANCE
Polarization	Simultaneous Horizontal and Vertical
Cross Polarization Components	>25 dB Below Signal
Calibration	Self Contained, Absolute
Calibration Accuracy	$\pm$ 3K, 175K $< T_{ANT} <$ 400K
Hot Reference Temperature	330K, Controlled $\pm$ 2K, Nominal
Cold Reference Temperature	273K, Controlled $\pm$ 2K, Nominal
Dicke Reference Temperature	303K, Controlled $\pm$ 2K, Nominal
RF Center Frequency	85.5 GHz (Tuneable $\pm$ 250 MHz)
Instantaneous IF Passband	100 to 1000 MHz
Input VSWR	1.28 : 1
Stop Band Attenuation	>40 dB at 1100 MHz
Mixer/Preamp DSB Noise Figure	$\leq$5.0 dB
Front End Losses	$\leq$2.5 dB
Integration Time (Selectable)	.001, .005, .01, .05, .1, .5, 1.0 seconds
Dynamic Range at Antenna	0 to 600K
ΔT_{min} (=.05 sec, T_A=300K, $\frac{\Delta G}{G} = 10^{-4}$)	
Dicke Mode	0.52K
Total Power Mode	0.29K
Antenna 3 dB Beamwidth	7 degrees
Antenna Beam Efficiency	93% at HPBW x 2.5
Output Voltage for T_A=0 to 400K	0 to +1 Vdc Nominal
Output Offset Adjustment Range	$\pm$ 10Vdc
Input Power	22 to 34 VDC, 300W max
Power Supply Noise Rejection	>50 dB (0.1 to 5 kHz)
Chopping Frequency	330 Hz

produce an input VSWR of 1.28:1. The outputs of the isolators are connected to the mixer inputs of the dual channel downconverter where the signals are mixed down to the IF band.

Antenna Components

The conical corrugated horn antenna produces the desired far field radiation pattern. The horn design resulted in an aperture phase error less than $\lambda/8$, a 3 dB beamwidth of 6.95 degrees and an overall beam efficiency of 93%. Figure 2 illustrates the designed horn antenna and its associated far-field pattern.

The antenna feeds an orthomode transducer that separates the polarization components. The transducer, built at Georgia Tech, is based on a design that has been used successfully in several systems. It consists of a split block with a circular through guide and a cross coupled standard waveguide port. A circular to waveguide transition is used to couple the energy out of the through guide. An isolator in each channel is included to maintain the required input VSWR. The isolation of these components (18 dB) in combination with the LO to RF isolation of the mixers results in an overall LO to RF isolation of 38 dB and an input VSWR of 1.28 : 1.

Calibration Components

The calibration components consist of free space absorptive reference loads formed by molding a ferrite/epoxy material on an aluminum backing plate. To allow operation with both polarizations, the loads have a surface made up of pyramids formed at the Brewster angle so as to maximize absorption for both polarizations. Similar loads built at Georgia Tech have demonstrated emissivities greater than .998 over wide bandwidths. A layer of low loss foam, bonded to the emissive surface, prevents condensation and corrosion of the load material and minimizes the power required to maintain the load temperature. For a 1/2 inch layer of styrofoam, L is approximately 0.15 dB including reflective losses. For each load, the temperature

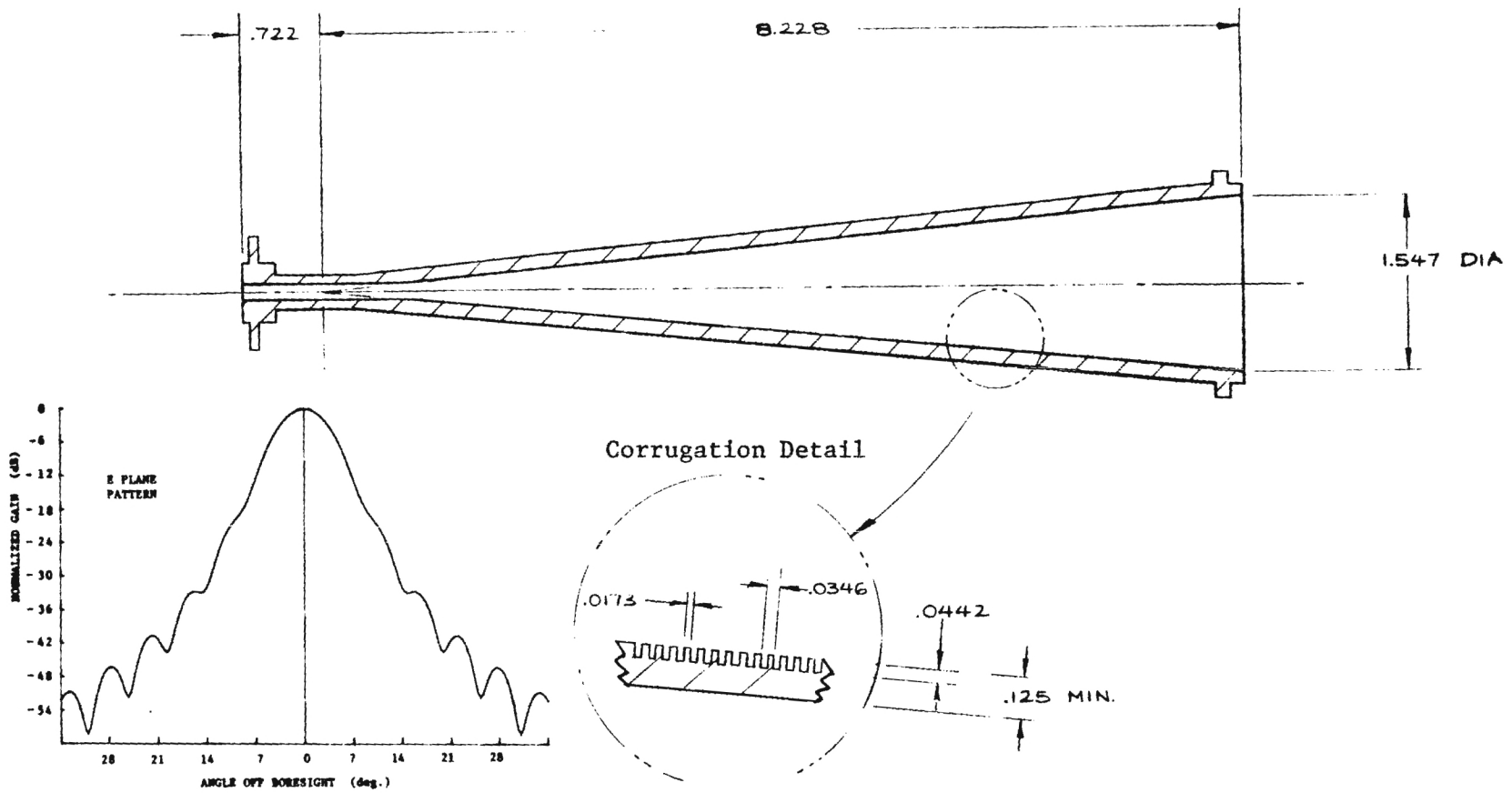

Figure 2. Conical Corrugated Horn Antenna & Pattern.

shift in the apparent radiometric temperature due to the foam loss is 0.5K maximum.

The hot load consists of a 5 inch square section of load material (described above) backed with power resistors and insulated with 1/4 inch foam. A solid state temperature transducer, embedded in the aluminum backing plate, provides a reading of the average load temperature with an accuracy of $\pm$0.3 K. The heater resistors are driven by a temperature controller in order to maintain the load temperature at a nominal value of 330 K. A thermostatic safety switch, mounted on the backing plate, shuts off current to the resistors if the temperature exceeds 340 K.

The cold load, identical in size to the hot load, uses a thermoelectric cooling module bonded to the backing plate. The module transfers heat from the cold surface (backing plate) to the opposite surface and uses the support bracket and radiometer base plate as a heat sink. To minimize the cooling load on the module, the entire assembly is sealed and insulated with foam. Measurements show that the cold load can be maintained at 273 K with an input current to the module of 5 amps. A solid state temperature transducer is used to read the average load temperature with an accuracy of $\pm$ 0.3 K. A unique property of the thermoelectric cooling module is its ability to transfer heat in a direction opposite the normal sense when the applied current is reversed. This property can be used to purge moisture from the load without disassembling it. The design of the temperature controller circuit is such that the cold load can be heated if the operator sets the desired temperature above the ambient temperature.

The Dicke reference load is physically identical to the hot and cold loads but is not directly heated. Instead, this load is heat sunk to the radiometer base plate and is warmed and controlled by the base plate heaters.

The required interval between calibration cycles depends on the gain stability of the system. Since the system gain fluctuation is generally device and temperature dependent, it is difficult to predict an exact value, and even measured values can display wide variations over the system's lifetime. To allow for this variation and to take advantage of the additional stability while operating in the Dicke mode, the calibration interval is operator selectable over a range of about 2 to 100 seconds. A separate front panel control adjusts the dwell (stare) time for each calibration load over a range of about 0.5 to 10.0 seconds.

The actual beam steering during calibration cycles is accomplished with a rotating plate having two reflectors. During a calibration cycle, the plate is rotated by a small stepper motor so that the radiometer first views the cold load for a time period determined by the setting of the dwell time control. At the end of this period the plate is rotated so that the beam views the hot load for the same dwell time. After this interval, the plate is again rotated so that the antenna views the scene through the hole in the plate. This position is maintained until the start of the next calibration cycle as determined by the calibration interval control setting. Optical sensors mounted on the plate assembly provide feedback to the calibration controller.

RF Downconverter Assembly

Table 2 summarizes the specifications for the dual channel downconverter assembly. Outputs from the preamplifiers are at about -65 dBm (for T_A = 400K) and thus require another 40 dB of gain to achieve a -25 dBm level at the input to the square law detectors. This gain is accomplished with an additional IF amplifier stage.

The local oscillator consists of a fundamental Gunn diode oscillator and a divider to distribute power to the mixers. The Gunn device ensures that amplitude and frequency drifts due to

TABLE 2

DUAL CHANNEL DOWNCONVERTER SPECIFICATIONS

RF Input	84.5 to 86.5 GHz
LO Input	85.5 GHz (Tuneable $\pm$ 250MHz)
IF Output	100 to 1000MHz
DSB Mixer/Preamp Noise Figure	5.0 dB max at 30°C
RF-IF Gain	15 dB min
Gain Variation	$\pm$ 1.0 dB (0 to 50°C)
Dynamic Range	Noise to -20 dBm
LO- RF Isolation	20 dB min
Operating Temperature Range	0 to 50°C

temperature change are less than 0.05 dB and 5.0 MHz respectively for a change in baseplate temperature of 1K. The local oscillator phase noise contribution to the overall system noise figure is minimal because the IF bands are separated from the center frequency by 100 MHz. For an LO output of +10 dBm and an antenna temperature of 300K, the phase noise components are 50 to 60 dB below the signal and can be disregarded.

The baseplate is temperature controlled to minimize temperature drifts in the local oscillator frequency and system gain. Typically, amplifier gain increases by about 0.015 dB for a temperature increase of 1K. Since the baseplate temperature is maintained at 303K $\pm$ 2.0K, the gain variations are negligible. The dynamic range of the RF/IF front end components allow the use of antenna temperatures from 0 to 600K assuming a -20 dBm maximum input at the square law detector.

2.2 IF/Video Subsystem

The post detection electronics for each polarization channel consists of a low-noise dc coupled video amplifier, steering switch, synchronous detector, integration filter, and wideband buffer amplifier. These components are Georgia Tech designs which have been previously used in several airborne and ground based radiometric systems.

Two 1.0 GHz, 17 section, low pass filters are used in conjunction with the post IF amplifiers to define the IF predetection bandwidth and ensure that aircraft RF sources above 1.0 GHz do not interfere with the radiometer signal. This approach prevents saturation and non-linearity in the post IF amplifier due to out of band signals and provides isolation between the two amplifier stages. Since the responses of the two filters add directly, the effective rolloff is twice that of a single filter. The signals are then square law detected prior to being routed to the video amplifiers.

Signals from the square law detector are increased to a useful level (≈1V) in the video amplifier and transferred to the remote control unit over a BNC cable. The output stage of the video amp is optimized for driving capacitive loads of the type presented by long cable runs to minimize distortion and phase shift in pulse waveforms.

A steering switch in the control unit selects between a Dicke or total power signal path depending on the position of the "Dicke/Total Power" control panel switch. The Dicke signal path includes a synchronous detector that multiplies the radiometer and chopper reference signals to reduce the contribution of uncorrelated noise components in the radiometer signal. By shifting the signal away from dc to the chopping frequency, this technique also eliminates the effect of long term gain variations and offset drift.

The total power mode signal path bypasses the synchronous detector and is connected directly to the integration filter and output buffer amplifiers. In this mode, the signal path is dc coupled and the chopper and reference signal are disabled. The integration filter consists of a second order state-variable network configured as a low pass filter with a Bessel response characteristic and switch selectable cutoff frequencies. Following is a description of each electronics circuit located in the radiometer housing package.

Calibration Interface Circuit (Drawing No. A-3434-CIC)

This circuit:

1) Receives the Dual Tone Multiple Frequency (DTMF) tones and converts them to a two bit word;
2) Compares the two bits from the DTMF receiver with the "A" and "B" bits generated by the HEDS 1000 sensors and turns the stepper motor on if they don't match;
3) Provides a summing point for the chopper reference tones and calib. state voltage and converts these to

differential signals to drive the CAL1 and CAL2 lines;

4) Actuates the chopper motor and solenoid depending on the level present at the Mode input.

U3 is a differential receiver that drives U4, a DTMF receiver. The outputs of U4 are two bits at pins 1 and 22. When a valid tone pair is detected over a period > 40 msec, these pins are updated and pin 18 is pulsed. The leading edge at pin 18 clocks the two bits into the latches in U5. The outputs of U5 drive a comparator circuit formed by U6 and U7. If the two bits from U5 don't match the "A" and "B" bits from the Chopper/Calib. Signal Generator Board, then the "Pulse Generator Output" is applied to the stepper motor "FWD" input and the motor runs. The motor will continue to run until the bits at the comparator inputs match. Diode D3 is used to derive +5V to power the CMOS IC's from +28V.

U1 and U2 are two inverting amplifiers configured as a differential line driver. The "Chopper Ref" and "Calib. State" voltages from the chopper/Calib. Signal Gen. Board are summed by U2 and output on lines CAL1 and CAL2.

Q1 converts the mode input to drive signals for the chopper motor and solenoid. Since activation of the solenoid while the chopper is running will destroy the chopper blade, it is important to prevent this occurance.

When the Mode input is @ 28V return, the Dicke mode is selected and Q2 is biased on (Q1 is off) and connects the chopper motor drive board to 28V return. R18 is used to sense chopper motor current and biases Q3 on when the motor is running. Q3 in turn opens relay K1 (N.C. contacts) to turn off the solenoid. Q4 controls the solenoid and is biased on when the Mode input selects Total Power and the time delay (60 sec) created by U8 expires. This allows time for the chopper blade to stop before the solenoid is actuated for Total Power mode.

Chopper Calibration Signal Generator (Drawing No. A-3434-CCS)

This circuit interfaces the HEDS1000 sensors to the calibration controller and generates the chopper reference and calibration state signals.

There are 3 identical HEDS1000 circuits on this board. The output of the HEDS1000 sensor is a small photo-current from pins 2 and 8 that is converted to a voltage by op amps U1 and U2. This voltage is negative and is inverted, amplified, and level shifted by the second op amp stage. At the output of the second stage, the voltage swing is sufficient to turn the associated NPN transistors on or off. Potentiometers R11, R21, and R32 should be adjusted so that the output swings from 0 to 1V at the base of the transistors when the HEDS1000 detects a reflection. Diodes D1, D2, and D3 prevent the base emitter junctions from becoming reverse-biased when the op amp outputs are negative.

The chopper reference signal is generated by U3, a monolithic function generator IC. The output frequency is determined by R7 and capacitors C11 and C12. These capacitors are connected in parallel with one side of C12 attached to the collector of Q1. When Q1 is on, both capacitors are grounded and the output frequency is a 72 kHz sine wave. When Q1 is off, C12 is removed from the circuit and the effective capacitance is reduced yielding a 116 kHz output frequency. Potentiometer R3 should be adjusted for best symmetry (i.e. lowest distortion) of the output waveform.

The outputs of the remaining two HEDS1000 circuits are used to generate a calibration state voltage. These sensors are mounted so as to sense the position of the calibration mirrors. As the stepper motor rotates the calibration mirrors, these sensors generate a 2 bit binary word corresponding to the calibration state (i.e.: hot load, cold load, scene, or intermediate). This word is transferred to U5, a CMOS one of four decoder that in turn drives U4, a quad analog switch. U4 is

connected to U1 to form a variable gain amplifier that outputs a voltage between 0 and 4.75 volts depending on the calibration state. Potentiometer R36 should be adjusted for 1.00V at the wiper. The following lists the calibration state voltages.

Calibration State	A	B	Output Voltage
Intermediate	1	1	0.00
Cold	0	0	1.75
Hot	1	0	3.25
Scene	0	1	4.75

2.3 Remote Control Panel Electronics

The 85.5 GHz radiometer control panel provides for operation of the radiometer remotely via the 50 foot cable between the two units. The control functions and power are supplied from a single chassis unit designed to be mounted in the standard 19 inch rack located on the NRL RP3-A aircraft. The control panel operates solely from +28Vdc unregulated aircraft power. A description of each circuit used in the control panel follows.

Phase Sensitive Detection (Drawing No. A-3434-PSD)

This circuit is used to synchronously detect the output of the radiometer when operating in the Dicke mode, and provide a low pass smoothing for both the Dicke and total power modes. An output stage also provides gain and offset adjustment for the output.

The chopper reference signal is conditioned and phase-adjusted in the digital portion of the circuit consisting of U7, U8, and U9. R32 is used to adjust the phase in conjunction with switch S1 which produces a 180 degree phase shift.

Half of U1 is used as an input buffer and bandpass filter for the input signal. The bandpass Q is $\simeq$ 10 so that signals within $\pm$5% of the center frequency are not attenuated. The center frequency is set by RBP resistors. An offset null stage

is provided at the output of the BPF to remove any dc offset present by adjusting potentiometer R10.

U2 acts as a multiplier and has a gain of 1 or -1 depending on the level of the input from the chopper reference circuit. Test point 2 (TP2) gives access to the output of the synchronous detector.

U3 is a dual-section analog switch that selects either the output of the synchronous detecter (Dicke mode) or the dc-coupled input signal (Total Power mode) depending on the level present at the Total Power/Dicke input.

The other half of U1 is configured as a lowpass filter (LPF) integrator. It has a Bessel response and the cutoff frequency is determined by RA and RB. U5 is the output drive stage and provides both gain (R23) and offset (R26) adjustments.

Temperature Controller Circuit (Drawing No. A-3434-TCC)

This circuit regulates the temperature of the hot load, cold load, and baseplate (Dicke reference load). It consists of three identical circuits on the board itself, and a power output stage that will be different depending on the type of load being driven.

Power for the circuit is derived from the +28Vdc supply and U1 is used to provide a moderate current "ground" point for the bipolar op amps. Since the output of U1 is always at half the supply voltage, it simulates the ground return in a dual supply setup. Although there is some noise on the 28 volt supply and this noise appears on the positive and negative rails, the op-amps power supply rejection are sufficient to minimize any effects.

U3 acts as a differential input amp that allows the signals from the thermistor amplifiers to be interfaced with the temperature controller circuitry. The output of this amplifier is a voltage scaled to 5 mV/K.

U4, U5, and R11 generate a reference voltage also scaled at 5 mV/K. R11 is a digital knobpot potentiometer mounted on the control panel and used to set the desired temperature. These potentiometers read in Kelvin degrees so that a setting of 300 should produce an output at pin 6 of U5 of 1.5000 Vdc (i.e. 300 K x .005V/K).

The voltages from the outputs of U3 and U5 are subtracted by U7 to generate a scaled error voltage of 1.0 V/K. The output of U7 should correspond in sign and magnitude to the difference between the actual and desired temperatures with a scale factor of 1.00 V/K.

U2 is a two pole low pass filter with a time constant of 30 seconds. It slows the changes in the error voltage presented to the high current output stages to minimize interference with low level circuits.

U2, Q1, and U6 sense the voltage level at the output of U3 and turn off the output drive if it is too low. The trip point is set by R5 and R6 at $\simeq$ 1.0 volts and corresponds to a temperature of 200K. Since it is very unlikely that a temperature this low will ever occur, an output below 1.0 volts probably means that the thermistor has been disconnected or has failed. When this level is reached, Q1 turns on and through U6, grounds the input to the low pass filter and removes the drive voltage. Additional over-temperature protection is provided by thermal cutout switches on the resistive loads which open at 65^{o}C (338K).

The output drive stage consists of one-half of U2 and a high current driver. The output of the low pass filter is inverted and scaled to provide an output drive voltage. The offset, or idle level also is adjustable at this point. A high current stage follows and is different depending on the load being driven. The resistive loads are tied to a Darlington (20A) transistor Q2 acting as an emitter follower. Since no current limiting is provided, care should be taken not to short the

emitter output to 28V return because the transistor can be destroyed.

The drive for the cooling module in the cold load consists of a bridge amplifier formed by two power op amps, U8 and U9. The module is a floating load for these amps and can be used to cool or warm the cold load. The action depends on the direction of current flow which, in turn, depends on the magnitude of the error voltage. Diodes D2 and D3 limit the voltage across the cooling module to ±12Vdc. It is important that the cooling module and the op amps are mounted on a good heat sink since they can be destroyed by high temperatures (>440K).

Calibration Timing and Control Circuit (Drawing No. A-3434-CTC)

This circuit:

1) Provides pull up resistors for the calibration interval/dwell time thumbwheel switches;
2) Generates the DTMF outputs for the calibration interface circuitry;
3) Detects the frequencies from the chopper/calibration generator circuit and converts these to a TTL chopper reference signal;
4) Drives the calibration monitor LEDs on the front panel;
5) Generates a 0-1V calibration state output signal for the BNC on the rear panel.

U3 is a DTMF (i.e. touch tone) generator that is controlled by the upper C-port of the octagon μ-computer. R26 adjusts the output level and U5 and U6 convert this to a differential signal and drive the CAL1 and CAL2 lines.

U4 is a differential amplifier that converts the differential signals present on the CAL1,2 lines to single ended, ground reference signals. Half of U1 comprises a lowpass filter with a cutoff $\simeq$ 250 Hz. The output of the LPF is scaled by two other op amps (the other half of U1) and is used to drive the LED

circuit and "Calib. State" BNC output. R48 adjusts the level at the BNC output and R82 adjusts the level sent to the LED circuit.

Three window comparators (U9, U10) drive the front panel LEDs through NAND gates and transistors Q2-Q4. U2 is a voltage reference that sets the overall response of the comparator circuit. An error flag input is gated into the LED drivers so that one of the three LEDs will flash if the computer determines there is an error in the switch settings.

U7 and U8 are PLL tone detectors which sense the 72 kHz and 116 kHz signals generated by the Chopper/Calibration Signal Generator Board. The outputs of these circuits are converted to a CMOS compatible level by U12 and Q1.

3.0 Radiometer Operation/Calibration/Maintenance

System Operation

The operation of the radiometer is controlled by the remote control panel when the following connections are made:

a) The power connector mounted on the rear panel of the remote control panel must be wired to 28Vdc, 10 ampere power with pin A of the power connector wired to +28Vdc and pin B of the power connector wired to 28V return. Pin C should remain open.

b) The 19 pin aircraft provided signal cable should be connected between the control unit and the radiometer.

c) Connect the "E" and "H" BNC signal inputs on the control unit (rear panel) to the radiometer "E" and "H" BNC signal outputs.

The following BNC outputs can be monitored on the remote control unit front panel (F.P.) and/or rear panel (R.P.):

BNC	Output Level
Filtered H (F.P./R.P.)	0 to 1 volt signal with ±15V offset; 33 msec time constant for filtered E & H
Filtered E (F.P./R.P.)	
Wideband H (F.P./R.P.)	
Wideband E (F.P./R.P.)	

Calibration Monitor Hot (F.P./R.P.)	(10 mV/^{o}K)(T_{HOT})
Calibration Monitor Cold (F.P./R.P.)	(10 mV/^{o}K)(T_{COLD})
Calibration Monitor Dicke (F.P./R.P.)	(10 mV/^{o}K)(T_{DICKE})
Calibration State (R.P.)	0.35V(COLD); 0.65V(HOT); 0.95V(Scene)
System Mode (R.P.)	15V(DICKE); 0V(TOTAL POWER)
Chopper Reference (R.P.)	TTL with 350 Hz freq.

The Hot, Cold, & Dicke Reference temperatures are displayed in ^{o}K on the front panel mounted liquid crystal display meters. The "E" and "H" output offset levels can be read out in DC volts using the front panel mounted meters. A front panel meter displays the Gunn Diode oscillator current in DC amperes.

Normal power on sequence is to turn on the "Master Power," "Gunn", and "Temp. Control" switches in that order. All three switches are located on the front panel of the remote control unit. Rear panel circuit breakers at +5V, and $\pm$15V should be engaged to insure the proper operation of internal power supplies located in the control unit. It is suggested that sufficient time (15 to 20 minutes) be allowed for the system to stabilize following the power on sequence. When the Hot, Cold, and Dicke temperature readings stabilize within $\pm 2^{o}$K of the thumbwheel switch settings, then the system is ready to take data.

System Calibration

The radiometer power should be on about 15 minutes to allow sufficient time for the calibration loads to stabilize. The following steps should be performed in order to determine the radiometer's sensitivity (ΔT_{min}):

a) Measure the output voltage at the "Wideband" BNC output when the radiometer is viewing the hot calibration load and when viewing the cold calibration load. Record $V_{H_{DC}}$ and $V_{C_{DC}}$ corresponding to hot load dc voltage and cold load dc voltage respectively. Also record $V_{C_{RMS}}$

which is the RMS voltage output at the "Wideband" BNC when viewing the cold calibration load.

b) The system gain (G) in ^{o}K/volt is now determined by

$$G = \frac{T_H - T_C}{V_{H_{DC}} - V_{C_{DC}}}$$

T_H = Hot Ref. Temp. Display (F.P.)
T_C = Cold Ref. Temp. Display (F.P.)

c) The radiometer sensitivity (ΔT_{min} in ^{o}K is given by

$$\Delta T_{min} = GV_{C_{RMS}}$$

d) The system noise temperature (T_{sys} in ^{o}K can be determined from

$$T_{sys} = \Delta T_{min}(B_{IF}\tau)^{\frac{1}{2}}$$, (for "total power" mode)

where τ = selected integration time (sec)
and B_{IF} = IF amplifier bandwidth

System Maintenance

Maintenance of the system involves routine checks of the electronic circuits used in the remote control unit and in the radiometer housing. The following adjustments to the circuits described in Sections 2.2 and 2.3 of this report are provided to insure proper operation of the system:

a) Temperature Controller Circuit (Refer to dwg. #A-3434-TCC)

1) The "zero" adjust potentiometer should be adjusted for zero volts at U7/6 when the front panel digital thumbwheel is set at the desired temperature setting;

2) The "offset" adjust potentiometer should be set for an output of +14.00 Vdc (relative to 28V return) at the temperature controller output (transistor Q_2 base);

3) The "gain" adjust potentiometer setting is a function of the desired response time and allowable temperature overshoot. For example, a gain setting of about 3 volts/^{o}K will allow the temperature controller to be set $\pm 5^{o}$K about the set point and still keep the output stage U_2 within its linear range.

b) Phase Sensitive Detector Circuit (Refer to dwg. #A-3434-PSD)

1) The "bandpass" adjust potentiometer (R10) should be adjusted so that the dc offset voltage at U1/5 is zero to eliminate any dc bias error at the synchronous detector stage (U2/8);

2) The "phase" adjust potentiometer (R32) should be adjusted for a <u>maximum</u> output at test point TP2. Note that changing the 180 degree phase shift switch S1 will result in a <u>minimum</u> output at TP2;

3) The adjustments for the "gain" (R23) and output "offset" (R26) depend on the desirable system gain and offset temperature. Adjust the "offset" for 0.6 volts at the PSD output (U5/6) when viewing the cold load (283^{o}K) and the "gain" for 0.9 volts at U5/6 when viewing the hot load (333^{o}K). This will provide a sufficient output change for anticipated radiometric temperature variations at the input. In addition the performance specifications of 0 to +1 volt maximum output voltage swing will be satisfied.

c) Chopper Calibration Signal Generator (refer to dwg. #A-3434-CCS)

1) In order to insure that the light emitting/detectors HEDS1000 are providing sufficient output current, the potentiometers R11

(Chopper), R21 (Cold), and R32 (Hot) should be adjusted to insure that the output transistors Q1-Q3 are switched on and off;

2) In the case of the chopper signal generator (U3), potentiometer R3 is adjusted to minimum distortion of the chopper output (U3/2);

3) Potentiometer R36 should be adjusted so that the voltage at U1/7 corresponds to the calibration state, i.e. 1.75V for cold load, 3.25V for hot load, and 4.75V for scene.

d) Calibration Interface Circuit (refer to dwg. #A-3434-CIC)

1) There are no internal potentiometer adjustments on this circuit which receives the CALIB1 and CALIB2 inputs from the remote control unit and transmits the CALIB1 and CALIB2 outputs to the control unit;

2) The control for the Total Power "solenoid" is located on this board. The relay K1 with normally closed contacts should be checked periodically to insure that the solenoid engages within 1 minute of switching from Dicke to Total Power mode.

e) Calibration Timing and Control Circuit (refer to dwg. #A-3434-CTC)

1) Potentiometer R26 is used to adjust the levels of the CAL1 and CAL2 outputs sent to the radiometer and should be adjusted for about 1.0 volt peak-peak output;

2) R74 should be adjusted for about 0.25 volt peak-peak at U7, U8/pins 3 to insure that the chopper reference output is the correct frequency;

3) By adjusting R82 for a maximum output of +5.00V, then the control panel LEDS will light properly during each calibration cycle;

4) Potentiometer R48 is an adjustment for the "Calib State Output" located on the remote control unit rear panel and is set for a maximum output of +1.00V.

4.0 Conclusion

Under this contract Georgia Tech designed, fabricated, tested, and delivered to the Navel Research Laboratory (NRL) an 85.5 GHz dual polarization Total Power/Dicke radiometer for use onboard NRL's P-3 aircraft. The program included monthly technical progress reports and radiometer operating and maintenance procedures as described in this final report. The appendix of this report provides a numerical listing of detailed documentation which has been generated during the course of this program. In addition, the original set of detailed circuit schematics and one copy were delivered to the designated technical officer on this program.

APPENDIX

LIST OF DRAWINGS DESCRIBING THE 85.5 GHz DUAL POLARIZATION RADIOMETER SYSTEM

Dwg. No. (*)	Size	Title
001	B	85.5 GHz Corrugated Horn
002	D	RF Baseplate Input Diagram
003	C	Orthomode Transducer & Matching Iris
004	C	Mirror Blade
005 **		
006	C	Hot/Cold Load Reflector
007	B	Base Block
008	C	Motor Plate
009	C	Chopper Bracket
010	C	Chopper Housing Cover
011	C	Chopper Housing
012	B	Solenoid Bracket & Plunger Cap
013	B	Positioner Cam
014	C	Chopper Blade
015	B	Horn Bracket
016	B	Waveguide Bracket
017	B	Mixer/LO Baseplate
018	B	Ref. Load Reflector
019	C	Machining Dwg-Reflector Assy
020	C	Backing Plate
021	B	H-Plane Bend
022	B	Ref. Load Bracket
023	C	Isolator Bracket
024	B	Mole Plate
025	D	Baseplate
026	C	Baseplate Cover
027	C	Cover Plate
028	C	Baseplate Rail
029	D	Side View Layout
030	B	Filter Bracket
031	B	Window Ring
032	B	Window Ring Clamp
033	C	Front & Rear Cover Modifications

*All drawing numbers preceded by A-3434 designator

**Drawing 005 obsolete

Dwg. No.	Size	Title
034	D	Outer Enclosure, Isometric View
035	D	Top View Layout
036	B	Cooling Plate
037	C	RF Package Block Diagram
038	C	Control Panel Front View
039	B	Horn Iris
040	D	Control Unit Front Panel Machining Diagram
041	C	Power Supply Module
042	B	Thermistor Amplifier
043	B	Isolator Bracket (Revised)
044	C	Transducer to Isolator Waveguide Section #1
045	C	Transducer to Isolator Waveguide Section #2
046	C	Isolator to Load Waveguide Section #1
047 *	C	Isolator to Load Waveguide Section #2
049 *	B	Circular to WR-10 Transition
051	B	Outer Window

*Drawings 048 and 050 obsolete